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(54) **Process for producing a CVD-SiO2 film according to a TEOS-O3 reaction.**

(57) In a process for producing a semiconductor device, deposition of a CVD-SiO_2 film (32) at a given first O_3 concentration according to a TEOS-O_3 reaction is followed by further deposition of a CVD-SiO_2 film (34) at a second O_3 concentration higher than the first O_3 concentration according to the TEOS-O_3 reaction to form a CVD-SiO_2 film having a predetermined thickness and a surface little uneven.

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PROCESS FOR PRODUCING SEMICONDUCTOR DEVICE

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a process for producing a semiconductor device, and more particularly to a process for depositing a CVD-SiO_2 film according to a TEOS-O_3 reaction.

Prior Art

Fig. 4 is an illustration of a conventional process for depositing a CVD-SiO_2 film according to a TEOS (tetraethyl ortho-silicate, $Si(OC_2H_5)_4$, an alkoxysilane) - O_3 reaction.

Fig. 4 (a) illustrates a polycrystalline silicon film 6 (hereinafter referred to in brief as a "poly-Si film") formed on a thermal SiO_2 film 4 formed in a surface portion of an Si substrate 2 through a heat treatment thereof. Examples of semiconductor devices including such a structure includes a MOS transistor comprising a gate SiO_2 film coresponding to the thermal SiO_2 film 4 and a gate electrode corresponding to the poly-Si film 6.

On the structure of Fig. 4 (a), a CVD-SiO_2 film 8 is formed as an interlayer insulating film according to the TEOS-O_3 reaction as shown in Fig. 4 (b).

It has been found out that the surface of the CVD-SiO_2 film 8 in perspective view of Fig. 4 (c), deposited according to the TEOS-O_3 reaction, is even, or smooth, in the areas where the underlying surface is of the poly-Si film 6 (see a partially enlarged view A), but often uneven, or rough, in the areas where the underlying surface is of the thermal SiO_2 film 4 (see a partially enlarged view B).

The data of Fig. 3 obtained through experiment by the inventors of the present invention shows a tendency for the surface roughness of such a CVD-SiO_2 film to increase particularly with an increase in the O_3 concentration in the TEOS-O_3 reaction.

The uneven surface of the CVD-SiO_2 film 8 sometimes causes stress to be put on wirings formed thereon with high liability thereof to undergo disconnection and the like, leading to low reliability of a semiconductor device.

Fig. 3 is a characteristic diagram showing the relationship between the ozone concentration and the surface state of CVD-SiO_2 film, wherein the abscissa represents the zone concentration (mol %) whil the ordinate represents th surface roughness (Å), which was examined in the xperiment by putting and running a probe on a CVD-SiO_2 film to measure a difference of altitud in the up-and-down movement of the probe.

The present inventin has been made in view of the foregoing problems of the prior art. Accordingly, an object of the present invention is to provide a process for depositing a CVD-SiO_2 film according to a TEOS-O_3reaction by which the unevenness of a CVD-SiO_3 film can be suppressed as much as possible.

SUMMARY OF THE INVENTION

In accordance with the present invention, there is provided a process for producing a semiconductor device, comprising depositing a CVD-SiO_3 film at a given first O_3 concentration according to a TEOS-SiO_2 reaction, and further depositing a CVD-SiO_2 film at a second O_3 concentration higher than the first O_3 concentration according to the TEOS-O_3 reaction.

The first O_3 concentration is preferably about 0.5 to 2 mol %, while the second O_3 concentration is preferably 4 to 7 mol %.

In the process of the present invention for producing a semiconductor device, the first O_3 concentration at the first stage of deposition of a CVD-SiO_2 film according to the TEOS-O_3 reaction is set as low as preferably about 0.5 to 2 mol %.

This makes the surface of the resulting CVD-SiO_2 film little uneven even on thermal SiO_2 film areas, if any, of an underlying surface as demonstrated by the characteristic diagram of Fig. 3 showing the relationship between the ozone concentration and the surface state of the CVD-SiO_2 film.

When the O_3 concentration is low, however, the film coverage around angular parts of stepped portions of the underlying surface, the moisture absorption characteristics of the film, etc. are insufficient. Accordingly, the film thickness is desired to be substantially irreducible minimum.

At the second stage, the second O_3 concentration is set as high as preferably about 4 to 7 mol % to further deposit a CVD-SiO_2 film according to the TEOS-O_3 reaction.

According to the foregoing procedure, the second-stage deposition at a high O_3 concentration undergo no substantial influences of the underlying thermal SiO_2 film areas, if any, to make the surface of the resulting CVD-SiO_2 film little uneven ev n on the th rmal SiO_2 film areas of th underlying surface because the thermal SiO_2 film is covered with th CVD-SiO_2 film with a surface little uneven, deposited at th first stage.

At the second stage, the CVD-SiO_2 film is deposited at the high O_3 concentration to a predetermined thickn ss necessary for the process of the present invention. For exampl , wh n it is used

as an interlayer insulating film, the CVD-SiO_2 film is deposited at the high O_3 concentration to a thickness suited for the interlayer insulating film.

The CVD-SiO_2 film formed at the high O_3 concentration is of high quality with low moisture absorption and with good coverage around angular parts of stepped portions of the underlying surface.

Thus, according to the process of the present invention, a highly reliable insulating film with a surface little uneven and good coverage all across the film can be obtained even if the underlying surface includes areas of a thermal SiO_2 film.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects, features and advantages of the present invention will be better understood from the following description taken in connection with the accompanying drawings, in which:

Fig. 1 is an illustration of a process for producing a semiconductor device in Example according to the present invention;

Fig. 2 is a schematic diagram illustrating an example of production equipment for use in the process of the present invention;

Fig. 3 is a characteristic diagram showing the relationship between the ozone concentration and the surface state of CVD-SiO_2 film; and

Fig.4 is an illustration of a conventional process for producing a semiconductor device.

DESCRIPTION OF PREFERRED EMBODIMENTS

The following Examples will now illustrate the present invention in more detail while referring to the accompanying drawings, but should not be construed as limiting the scope of the invention.

Fig. 1 illustrates a CVD process using the TEOS-O_3 reaction in Example according to the present invention, while Fig. 2 illustrates an example of production equipment for use in the CVD process of the present invention.

The equipment of Fig. 2 comprises mass flow controllers (MFC) 10a and 10b, valves 12a to 12d, an ozone generator 14 wherein oxygen (O_2) is converted into ozone (O_3), a resorvoir 16 for a TEOS solution which is kept at a temperature of 40 to 65 °C, and a CVD chamber 16.

The CVD chamber 16 includes a heater 18, a gas outflow head 20, and a gas discharge outlet 22. Wafers 24a and 24b to be subjected to film formation are in place in the chamber 16.

The procedure of CVD-SiO_2 film deposition in the equipment of Fig. 2 is as follows. The valves 12a and 12b are opened. This entails generation of O_3 gas in the ozon generator 14, from which the O_3 gas is fed int the chamber 16 through the gas inflow head 20, through which TEOS gas on a carrier gas N_2 is also fed into the chamber 16. The TEOS gas is decomposed with the aid of the O_3 gas on the wafers 22a and 22b to deposit CVD-SiO_2 films on the surfaces of the wafers 22a and 22b.

The O_3 concentration may be changed by controlling the amount of conversion of O_2 into O_3 in the ozone generator 14, or by appropriately adjusting the mass flow controller (MFC) 10a as well as tho valves 12a and 12b.

The process for forming a CVD-SiO_2 film in this Example according to the present invention will now be described while referring to Fig. 1.

As shown in Fig. 1 (a), an Si substrate 26 is heat-treated to form a thermal SiO_2 film 28 to serve as a gate insulating film, followed by deposition of poly-Si according to a CVD method and subsequent patterning thereof to form a poly-Si film 30 to serve as a gate electrode.

Subsequently, a CVD-SiO_2 film is deposited using the equipment of Fig. 2. The substrate temperature is first set at 400 °C with the heater 18. The O_3 concentration is initially set to be about 1 mol % to deposit a CVD-SiO_2 film 32 as shown in Fig. 4 (b). The thickness of the film 32 may be satisfactory in so far as the thermal SiO_2 film 28 can be covered therewith, and is as small as, for example, 1,000 Å.

Subsequently, the O_3 concentration is increased to about 5 mol %, at which a CVD-SiO_2 film 34 is then deposited as shown in Fig. 4 (c). The thickness of the film 34 is desired to be as large as, for example, about 6,000 Å to be on a level of thickness required of an interlayer insulating film.

Even at such a high O_3 concentration, the underlying thermal SiO_2 film 28 exerts no substantial influences on the CVD-SiO_2 film 34 because it is perfectly covered with the CVD-SiO_2 film 32 (formed at the O_3 concentration of about 1 mol %). Thus, the surface of the CVD-SiO_2 film 34 (formed at the O_3 concentration of about 5 mol %) is little uneven.

The CVD-SiO_2 film 34 (formed at the O_3 concentration of about 5 mol %) shows a deposition form of flowing profiles around angular parts of stepped portions of the poly-Si film 30 with excellent coverage, and is of high quality with reduced moisture absorption.

In this Example according to the present invention, the surface of the CVD-SiO_2 film 34 (formed at the O_3 concentration of about 5 mol %) can be made even, or smooth, even on the surface areas of the thermal SiO_2 film 28, included in the underlying surface, without undergoing any unfavorable influenc s of the underlying surface, while providing good film quality and coverage characteristics.

As d scribed hereinbefore, according to the process of the present invention, the first stage of covering the underlying surface including the surface areas of the thermal SiO_2 film, if any, with a CVD-SiO_2 film deposited according to the TEOS-O_3 reaction at a low O_3 concentration is followed by the second stage of further depositing a CVD-SiO_2 film with good film quality and coverage characteristics according to the TEOS-O_3 reaction at a high O_3 concentration to form an insulating film having a predetermined thickness for the purpose of avoiding the unfavorable influences of the underlying surface. This enables formation of an insulating film with a surface little uneven, endowed with satisfactory characteristics of an SiO_2 film formed according to the TEOS-O_3 reaction at a high O_3 concentration. This enables production of highly reliable semiconductor devices with reduced stress put on wirings and the like formed thereon.

Claims

1. A process for producing a semiconductor device, comprising depositing a CVD-SiO_3 film at a given first O_3 concentration according to a TEOS-SiO_2 reaction, and further depositing a CVD-SiO_2 film at a second O_3 concentration higher than said first O_3 concentration according to the TEOS-O_3 reaction.

2. A process for producing a semiconductor device as claimed in claim 1, wherein said first O_3 concentration is about 0.5 to 2 mol %, while said seccond O_3 concentration is about 4 to 7 mol %.

FIG. 1 (a)

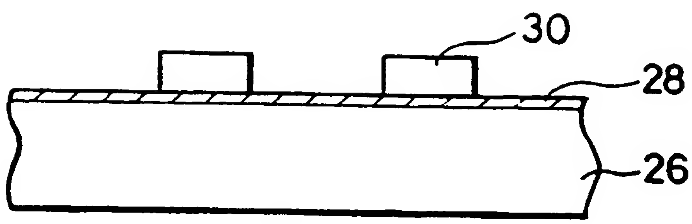


FIG. 1 (b)

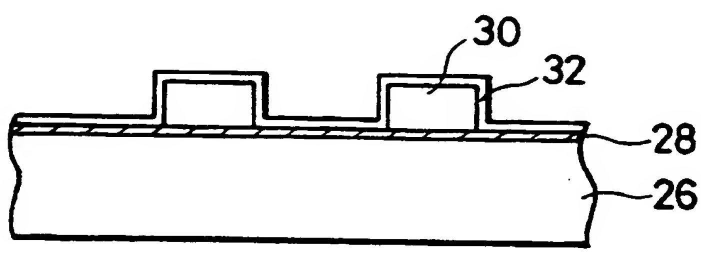


FIG. 1 (c)

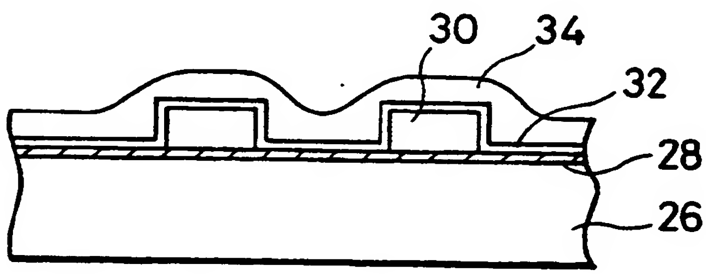


FIG. 2

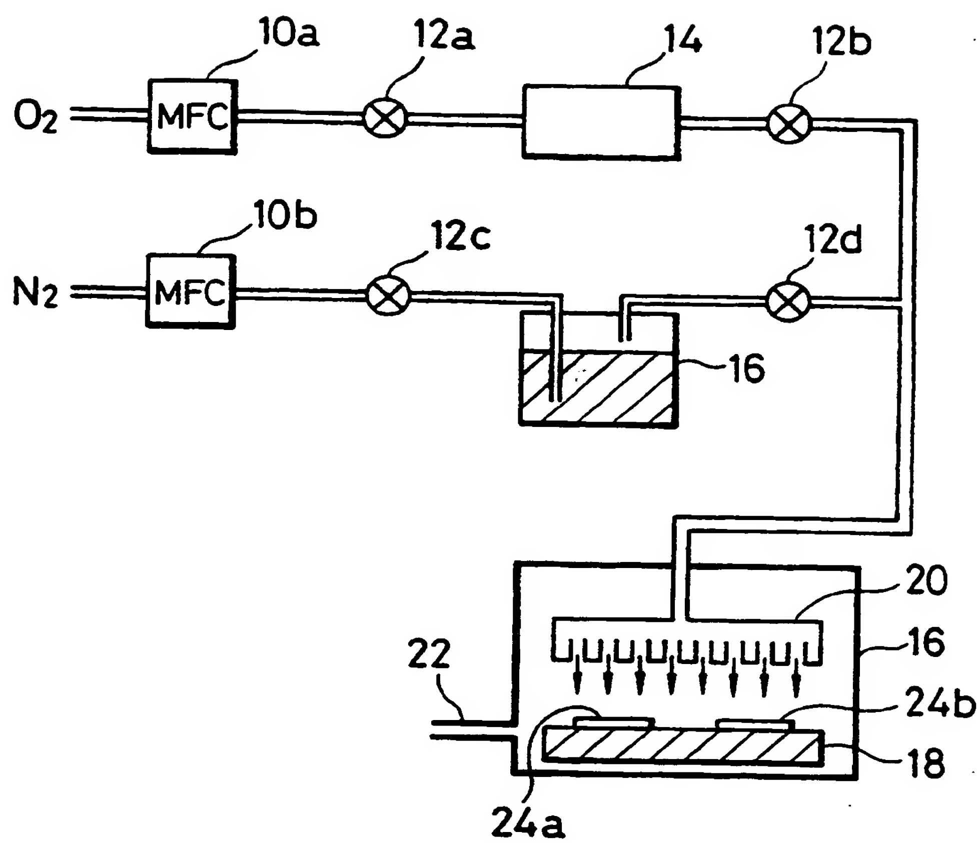
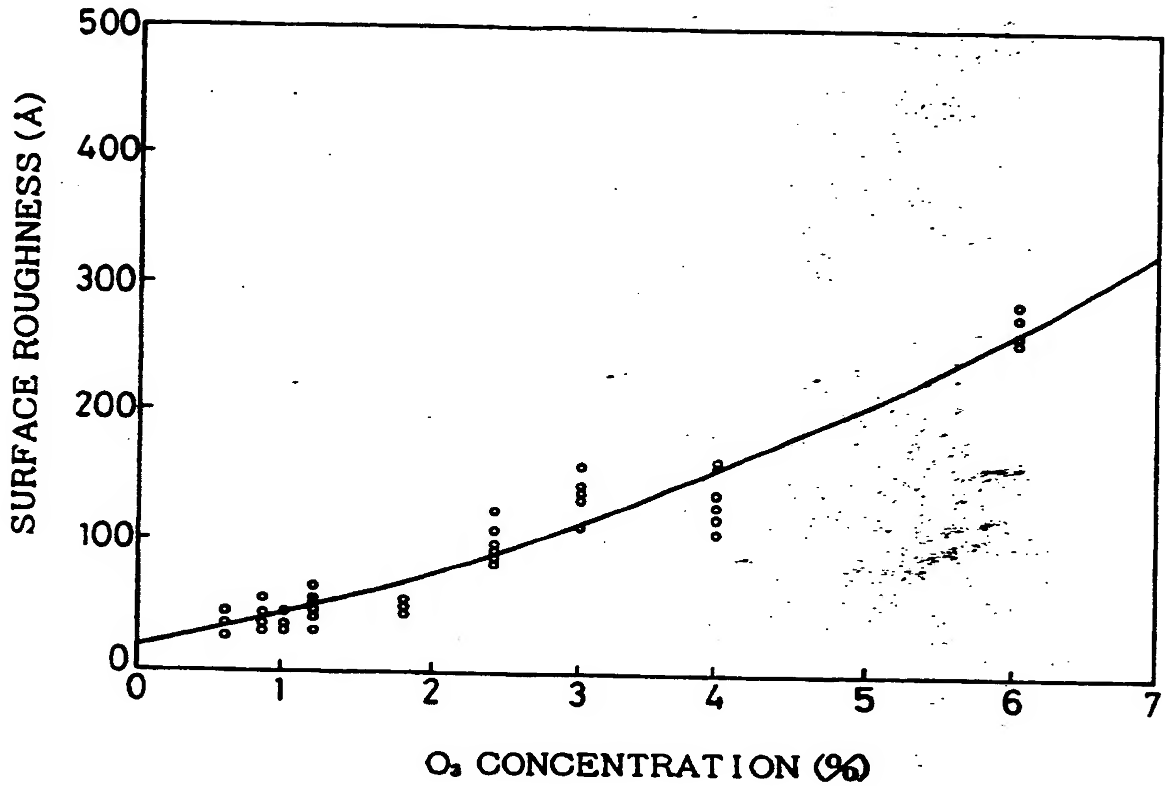
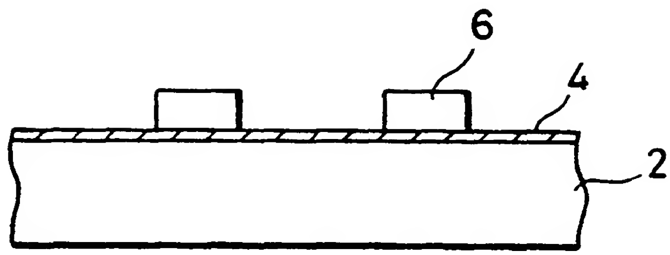


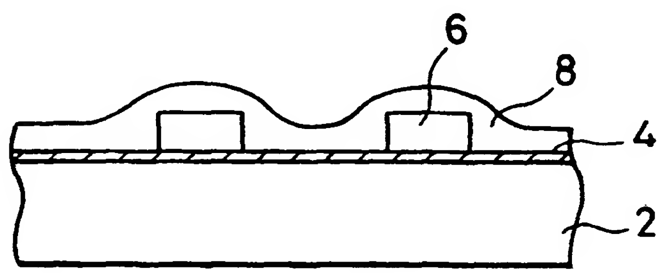
FIG. 3


500
400
300
200
100
0
SURFACE ROUGHNESS (Å)
0
1
2
3
4
5
6
7
O3 CONCENTRATION (%)

FIG·4(a)



FIG·4(b)



FIG·4(c)